# Spatial Analysis of Soil Properties for Precision Agriculture in Clay County, Nebraska

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### ABSTRACT

Ten soil and site properties were examined at 190 points in a 32-ha field in Nebraska during March 1999. Values were measured for eight properties and estimated for three properties. Field data were collected using both a GPS unit and a hand-held electronic data recorder. Combine vield data for corn were collected prior to the study. Using the ArcView 3.0 Spatial Analyst, each of the properties was interpolated to create surface maps. An order 1 soil survey map was also completed. Soil drainage class, slope gradient, and thickness of the mollic colors had the best relationship to the interpolated yield map. Thickness of the crust migrated across every yield contour in a random pattern and was not deemed important. Data from this study infer that collecting point data for soil properties can assist in understanding the yield differences within a field.

# BACKGROUND

An aligned grid consisting of 19 columns from west to east and 10 rows from north to south was inventoried for soil properties by the NRCS Precision Ag Team on March 16-17, 1999. Properties assessed included thickness of mollic epipedon, presence of a silt loam surface, Munsell color notation, presence of a traffic pan, crust thickness, clay content at 10 cm, maximum clay content in the Bt horizon, soil drainage class, water (path), percent slope, and slope aspect in degrees azimuth.

## STUDY AREA

The study area is in Clay County, Nebraska (Figure 1). It is located southeast of Clay Center. A 32-ha field was inventoried for soil and site properties. The rows (planted east/west) are 76 cm from ridge center to ridge center. The ridge till system in the study area began in 1986 and it has 15-cm valleys. The rotation is corn and soybeans. All of the soil observations were made on the north side of the ridge -- 7.5 cm down from the top. There is a flat ridgetop and 25-cm slide slopes. The planter is 12 rows wide. This system controls the traffic in the field. There is also a center-pivot irrigation system in the field to add water where the soil is dry (Figure 2).

# METHODS

Random sample points were assigned and flagged in the 32-ha field similar to previous SSM studies conducted by the NRCS Precision Ag team (Mount et al., 1999). Data from all sites were recorded with an electronic field tool that was downloaded into a laptop computer. Data were then exported to a database software for analysis.

The thickness of the mollic surface was determined using a Munsell color book and an oakfield auger. The color of the topsoil was determined with a Munsell color book. At 50 of the 190 points, an ochric epipedon was encountered as defined by *Soil Taxonomy* (Soil Survey Staff, 1999).

The estimated texture of the soil surface was documented at each point. A value of '0' was given for textures other than silt loam and a value of '1' was given for silt loam. In all cases, where the surface texture was not silt loam, it was estimated to be silty clay loam.

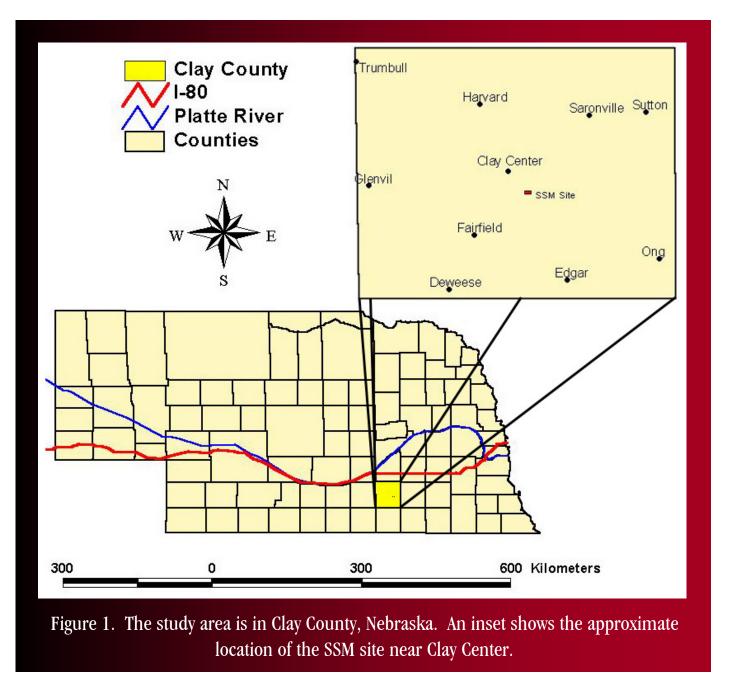
There are many plow pan types in agricultural fields of the United States. Some reside beneath the surface soil and others are formed in the soil surface. In this study, the presence of a traffic pan in the surface layer was identified as a '0' for no pan and a '1' for a pan.

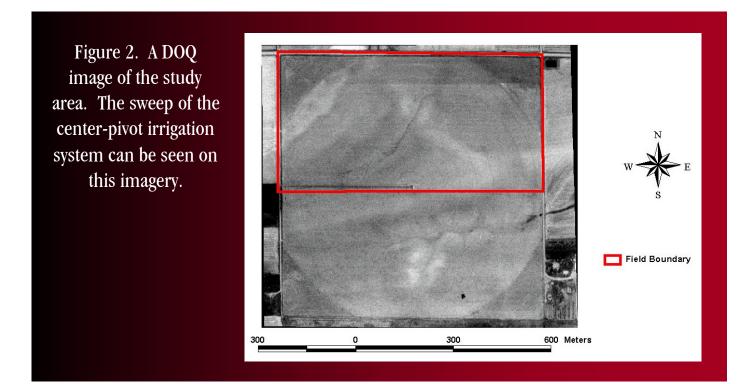
Soil crusting is common in soils of the Great Plains where winters are long and the soil surface contains more than 30 percent clay. The particular type of crusting identified in this study area was a freeze-thaw crust. In all cases it was associated with a polygonal cracking pattern averaging 10 cm in diameter. Crust thickness was measured to the nearest 1 cm.

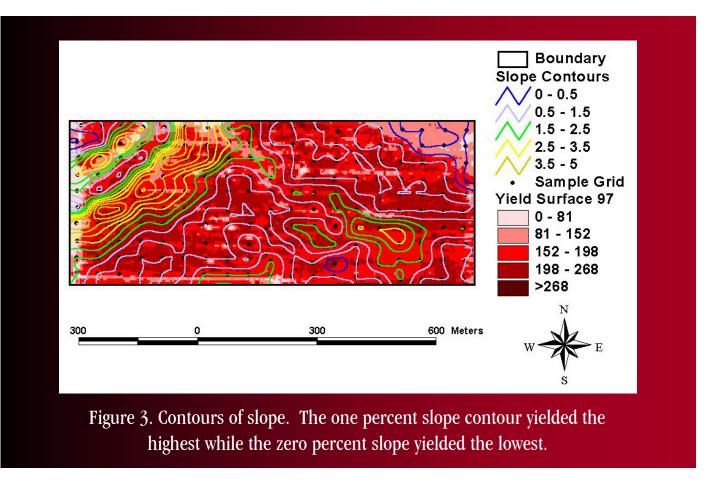
The clay content at 10 cm and the maximum clay content in the subsoil was estimated for each point.

Hydrology or water movement from the point of observation was identified. A '0' indicated a run-in situation, a '1' indicated a run-through situation, and a '2' indicated a run-off situation. The genetic tracks of the subsoil colors and its landscape position determine assessment of soil drainage. Poorly drained soils have a Munsell chroma of 2 or less, while somewhat poorly drained soils are also dull-colored but have a few zones of chroma of 3 or higher. Moderately well drained soils in the study area have mottles of chroma of 2 or less but their matrix colors are 3 or more. Soil drainage class was assessed as moderately well, somewhat poor, and poor. For this study, a poorly drained soil was given '0', somewhat poorly drained assessed as '1', and moderately well drained soils assessed as '2.'

Percent slope was measured with a clinometer and the azimuth degrees of the aspect was determined at each point using a compass.

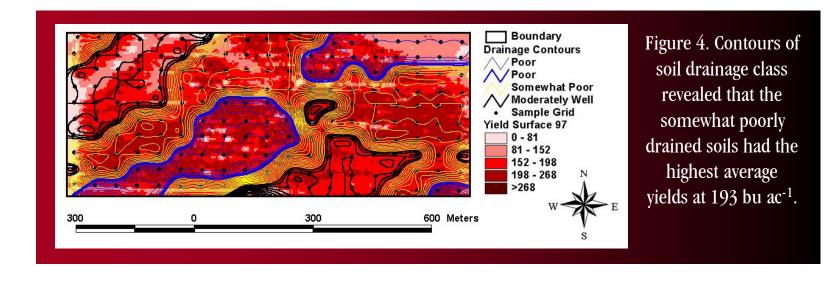


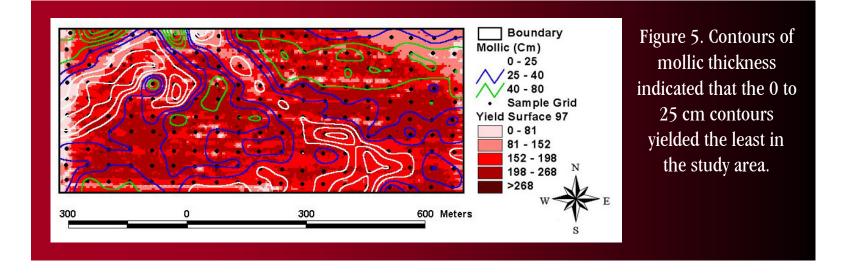


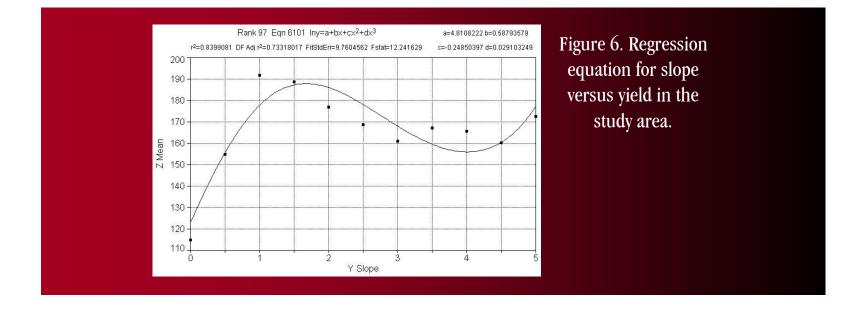


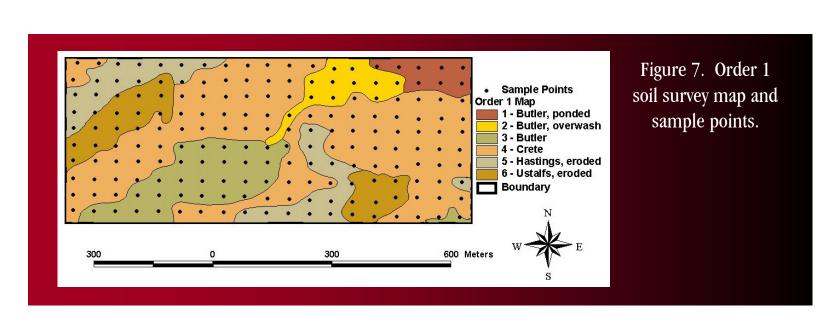
### Table 1. Analysis of soil and site properties from the 190 points in the study area.

Analysis (Kind)	Mollic Thick (cm)	Surface Texture (Type)	Munsell Color (Value)	Plow Pan (Y/N)	Crust Thickness (cm)	Clay 10 cm (%)	Clay Subsoil (%)	Drainage Class (Type)	Water (Path)	Slope (%)	Aspect (Deg.)
Mean	33.9	0.5	2.8	0.6	0.6	28.8	36.4	1.0	1.0	1.7	115.3
Median	36.0	0.0	3.0	1.0	0.5	30.0	35.0	1.0	1.0	1.0	68.0
StDev	17.4	0.5	0.6	0.5	0.3	4.1	3.4	0.7	0.4	1.1	98.4
Max	80.0	1.0	5.0	1.0	2.0	35.0	45.0	2.0	2.0	5.0	338.0
Min	0.0	0.0	2.0	0.0	0.0	20.0	25.0	0.0	0.0	0.0	0.0
Max - Min	80.0	1.0	3.0	1.0	2.0	15.0	20.0	2.0	2.0	5.0	338.0









# Table 2. Analysis of yield data and standard deviation for selected soil and site property in the study area.

Yield (Bu/Ac) Stand Dev. Acres Hectares

Soil & Site Property

**Poorly Drained** 

Somewhat Poorly Drained	193	33	37.2	15.1
<b>Moderately Well Drained</b>	166	45	23.2	9.4
0-90 Aspect	191	30	42.9	17.3
90-180 Aspect	187	30	17.8	7.2
180-270 Aspect	170	49	17.6	7.1
270-360 Aspect	180	44	1.7	0.7
0% Slope	115	25	2.1	0.9
0.5% Slope	155	29	2.5	1.0
1.0% Slope	192	29	20.7	8.4
1.5% Slope	189	29	13.9	5.6
2.0% Slope	177	33	12.3	5.0
2.5% Slope	168	39	8.0	3.2
3.0% Slope	161	41	6.6	2.7
3.5% Slope	167	43	4.7	1.9
4.0% Slope	166	43	4.0	1.6
4.5% Slope	160	32	3.3	1.3
5.0% Slope	172	28	1.9	0.8
0 Cm Mollic	168	43	6.0	2.4
10 Cm Mollic	162	43	7.7	3.1
20 Cm Mollic	163	44	13.3	5.4
30 Cm Mollic	180	39	18.6	7.5
40 Cm Mollic	190	39	18.1	7.3
50 Cm Mollic	175	47	11.6	4.7
60 Cm Mollic	178	41	3.5	1.4
70 Cm Mollic 80 Cm Mollic	172 172	39 30	$\begin{array}{c} 0.9 \\ 0.4 \end{array}$	0.3 0.2
25% Surface Clay	190	38	34.1	13.8
30% Surface Clay	169	48	29.2	11.8
35% Surface Clay	178	30	16.7	6.8
25% Subsoil Clay	91	21	0.4	0.1
30% Subsoil Clay	168	51	8.0	3.2
35% Subsoil Clay	175	43	36.8	14.9
40% Subsoil Clay	191	33	34.2	13.8
45% Subsoil Clay	182	7	0.7	0.3
1.5 Albedo	40.6	4.80	0.0	0.0
2.0 Albedo	186.7	31.34	15.1	6.1
2.5 Albedo	196.8	33.02	16.6	6.7
3.0 Albedo	184.4	30.59	31.0	12.6
3.5 Albedo	167.1	33.81	9.8	4.0
4.0 Albedo	165.8	28.77	6.7	2.7
4.5 Albedo	63.6	37.39	0.5	0.2
5.0 Albedo	40.0	4.98	0.2	0.1

#### Table 3. Analysis of yield data (bu/ac) based on the order 1 soil survey map.

Taxonomic Unit	MIN	MAX	RANGE	MEAN	STD	Acres	Hectares
1 Butler, ponded	57.0	227.5	170.5	113.9	22.9	3.3	1.3
2 Butler, overwash	16.0	333.8	317.8	187.2	33.3	4.8	1.9
3 Butler	3.6	351.9	348.3	195.3	32.0	11.8	4.8
4 Crete	10.7	486.2	475.5	190.4	36.8	41.0	16.6
5 Hastings, eroded	8.1	239.7	231.6	155.3	51.6	10.6	4.3
6 Ustalfs, eroded	1.7	369.0	367.3	170.4	39.8	8.4	3.4

# ANALYSIS & CONCLUSIONS

Analysis for this study began with summarizing the data for each soil and site property (Table 1).

Point data indicate that about half of the field has a silt loam texture (90 points) and the other half (100 points) are silty clay loam. Although the maximum slope for the study area is five percent, the mean slope is only 1.7 percent.

The ArcView spatial analyst allows a user to define zones of yield by contours. On average, the 32-ha field in this study area yielded slightly more than 180 bushels per acre. Table 2 presents the yield and standard deviation for each soil and site property on the study area.

The soil and site properties that correlated best to yield were slope, drainage class, and thickness of the mollic epipedon (Figures 3, 4, and 5). Properties that correlated the worst included crust thickness and plow pan.

A regression equation was developed for yield versus slope (Figure 6). With an R<sup>2</sup> of 0.84, this equation identified the trend of slope to yield.

An order 1 map was prepared for the study area after evaluating the grid data (Figure 7). Three taxonomic units, six map units, and 13 individual polygons were defined for this map.

On average, the somewhat poorly drained Crete soil, the poorly drained Butler, and Butler overwash soils yielded the highest. The well drained Ustalfs and Hastings. Map unit 1 (Butler ponded) yielded the worst at 113.9 bushels per acre. The eroded Ustalfs with an ochric epipedon yielded 15 bushels per acre higher than the eroded Hastings map unit with a minimal mollic epipedon. Table 3 presents these data.

The most important conclusion from this study is that the order 1 soil survey map was of value but less helpful in the analysis of the yield data than the soil and site information collected along the aligned grid of 190 points.

### ACKNOWLEDGEMENTS

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### REFERENCES

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